Assessing the Relationship between Habitat and Biological Communities in Virginia Streams Using Relative Bed Stability

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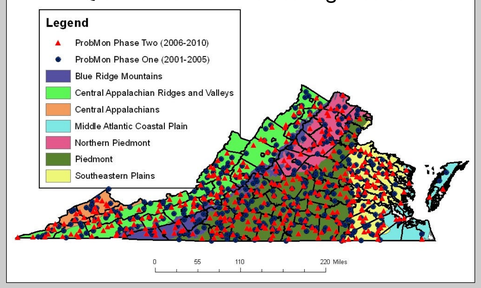
How is Virginia Quantifying Sediment in Streams?

In 2001, the Virginia Department of Environmental Quality (VDEQ) implemented a probability-based monitoring program (ProbMon) as an addition to existing targeted and watershed based water quality monitoring programs. ProbMon was initiated to determine the extent of water quality problems with statistical accuracy and to test new water quality monitoring and assessment tools. Anthropogenic sedimentation is recognized as a leading cause of water quality degradation; however, separating natural condition versus excessive anthropogenic sedimentation is difficult. USEPA's Relative Bed Stability (RBS) index allows for the evaluation of human activities in stream bed sedimentation by calculating the natural streambed particle size and compares it to the existing sediment load. VDEQ examined RBS, benthic macroinvertebrate, rapid bioassessment habitat, and land cover data at 138 ProbMon stations. VDEQ found the RBS index was able to distinguish between streams with substantial riparian and basin disturbance and those streams that were in approximate balance between sediment supply and transport. VDEQ identified relationships where biological communities were impacted due to excessive sedimentation.

DEQ's Probabilistic Monitoring Network

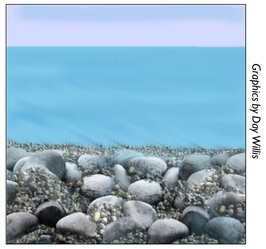


The Impact of Sediment on Benthic Habitats ...

In a healthy stream, spaces between rocks provide habitat for benthos ...

As fine sediment begins to accumulate, this habitat is reduced ...

Interstitial spaces are beginning to fill in ...



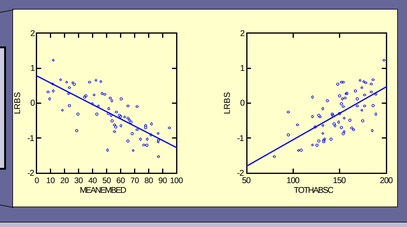
Benthic habitat completely fills in as fine sediment settles out.

Graphics by Day Willis

Sedimentation is one of the most prevalent impacts to benthic communities. Excess sediment fills interstitial spaces in between stream substrates used by aquatic organisms for habitat. Until recently, tools for rapidly quantifying sedimentation impacts in streams have been inadequate. Methods existed for describing dominant particle size, but it was difficult to differentiate between natural conditions and anthropogenic problems. Virginia has a variety of stream types; many are naturally sand/silt bed streams, so simply measuring the size of the sediment particles cannot differentiate natural and human-influenced sediment load.

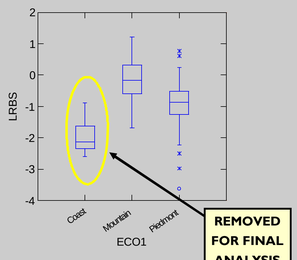
How Does Relative Bed Stability Compare to Other Habitat Measures?

Good Correlation with Total Habitat Score and Mean Embeddedness



What is Relative Bed Stability?

USEPA developed a tool for predicting the expected substrate size distribution for streams. This method incorporates stream channel shape, slope, and sediment supply. The method calculates a 'stream power' based on channel measurements that predict the expected sediment size distribution. The logarithm ratio of the observed sediment to the expected sediment is a measure of the relative bed stability (LRBS). An LRBS near zero indicates the stream is stable. However, increasingly negative numbers indicate excess sediment.



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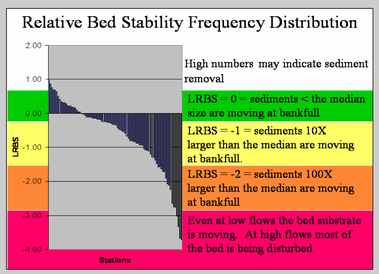
Relative Bed Stability Frequency Distribution



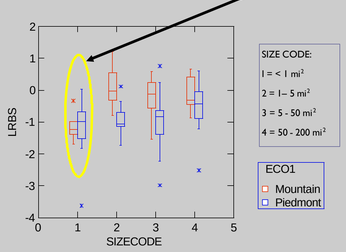
High numbers may indicate sediment removal

LRBS = 0 = sediments < the median size are moving at bankfull

LRBS = -1 = sediments 10X larger than the median are moving at bankfull.

LRBS = -2 = sediments 100X larger than the median are moving at bankfull

Even at low flows the bed substrate is moving. At high flows most of the bed is being disturbed



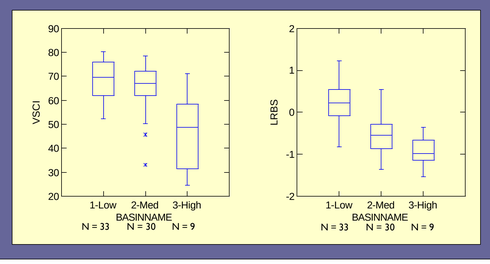
Does Basin Disturbance Affect Relative Bed Stability?

Basin Disturbance Index:

Condition	Source	0 Low	1 Medium	2 High
% Watershed Urban	GIS	<1%	1-5%	>5%
% Watershed Ag	GIS	<10%	10-40%	>40%
% Watershed Forest	GIS	>90%	50-90%	<50%
Road Density	GIS	<1 km/km²	1-2 km/km²	>2 km/km²
% Mean Embeddedness	EMAP	<50%	50-70%	>70%
Bank Condition	RBP	>17	14-17	<14
Bank Vegetation	RBP	>16	13-16	<14
Riparian Vegetation	RBP	>15	10-15	<10
Sedimentation	RBP	>16	13-16	<13
Total Habitat Score	RBP	>160	130-160	<130

Basin Disturbance Score 0-20

(0-8 Low, 9-14 Med, 15-20 High Disturbance)



Virginia's Stream Diversity

How Does Relative Bed Stability Relate to the Benthic Community?

Pearson Correlation Coefficient Table

	LRBS	% FINES	MEAN PARTICLE SIZE	MEAN EMBED
TOTTAXA (VSCI)	0.223	-0.042	0.248	-0.220
EPTTAX (VSCI)	0.348	-0.277	0.434	-0.412
%EPHEM (VSCI)	0.044	-0.132	0.101	-0.136
%PTHYDROP (VSCI)	0.378	-0.321	0.432	-0.378
%SCRAP (VSCI)	0.125	0.061	-0.008	-0.008
%CHIRO (VSCI)	-0.287	0.294	-0.311	0.289
MFBI (VSCI)	-0.329	0.248	-0.345	0.332
%EPT	0.055	-0.413	0.291	-0.336
%EPTHYDRO	0.255	-0.296	0.333	-0.331
EPTTAXHYD	0.348	-0.264	0.423	-0.406
SIMPSONS	0.211	-0.093	0.242	-0.232
%SHREDDER	0.113	-0.071	0.253	-0.190
%BAETIDAE	-0.086	0.025	0.014	0.039
%ZDOM (VSCI)	-0.279	0.094	-0.279	0.255
%SDOM	-0.356	0.192	-0.381	0.382
%HAPTO	0.323	-0.515	0.455	-0.469
%PRED	0.162	-0.171	0.219	-0.199
%CLLCT	0.018	-0.016	0.008	0.014
%HYDRO	-0.181	-0.107	-0.038	-0.005
%TOLER	0.031	0.258	-0.189	0.229
%PLECO	0.281	-0.312	0.447	-0.402
%FILTR	-0.205	0.012	-0.129	0.103
%OLIGO	0.058	0.120	-0.050	0.130
%DIPTERA	-0.354	0.379	-0.362	0.369
%CLNGP	0.130	-0.316	0.249	-0.285
%CLNG-HYDRO-SIM	0.188	-0.163	0.190	-0.283
VSCI	0.370	-0.242	0.398	-0.377

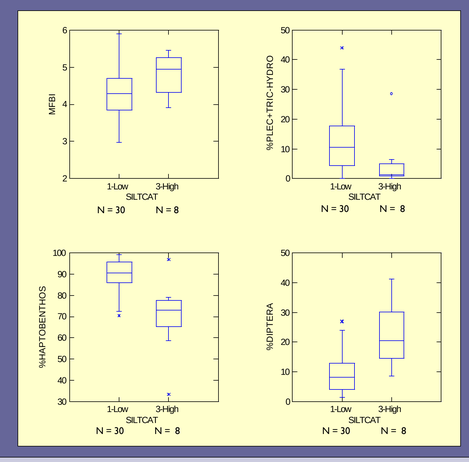
Silt Index

Condition	High	Fair	Low
% Fines	>75%	50-75%	<50%
LRBS	<-1	-1 to -0.5	-0.5 to 1
Logged Mean Substrate Size	<0	0-0.5	>0.5
Mean Embeddedness	>75%	50-75%	<50%

0-8 Score (0-2 Low, 6-8 High Sediment Disturbance)

Indicator Family Table

Taxa	Group	Indicator Value	Mean	SD	P-Value
Psephenidae	Low Silt	79.2	43.2	7.95	0.001
Perlidae	Low Silt	60.7	42.1	8.19	0.029
Rhyacophilidae	Low Silt	43.7	28.2	8.29	0.065
Corydalidae	Low Silt	50.3	38.7	8.6	0.114
Leptophlebiidae	Low Silt	38.2	27.7	7.82	0.119
Gomphidae	High Silt	53.6	22	7.79	0.008
Chironomidae A	High Silt	71.7	57.1	5.54	0.014
Dixidae	High Silt	25	5.8	3.66	0.018
Calopterygidae	High Silt	25	6.2	3.82	0.019
Empididae	High Silt	32.1	11.8	5.93	0.036
Cambaridae	High Silt	30.9	17.3	6.88	0.044
Corbiculidae	High Silt	26.6	16.2	6.34	0.069
Ptilodactylidae	High Silt	21.4	9.8	4.39	0.105
Caenidae	High Silt	23.4	17.3	7.2	0.111



What Conclusions Did DEQ Draw from this Analysis?

- Difficult to determine LRBS patterns in headwater streams (<1 square mile)
- Need more data from low gradient streams (>3% wetland)
- LRBS has moderate to good correlations with several RBP habitat metrics related to human impacts in a watershed
- LRBS is moderately correlated to several key biological metrics
- Need more data from stressed watersheds to better evaluate biological correlations
- Virginia's multimetric index (VSCI) has 5 metrics with weak correlations to decreasing LRBS values
- LRBS, Embeddedness, and % Fines can be used to determine when sediment has become a stressor

http://www.deq.virginia.gov/probmon/